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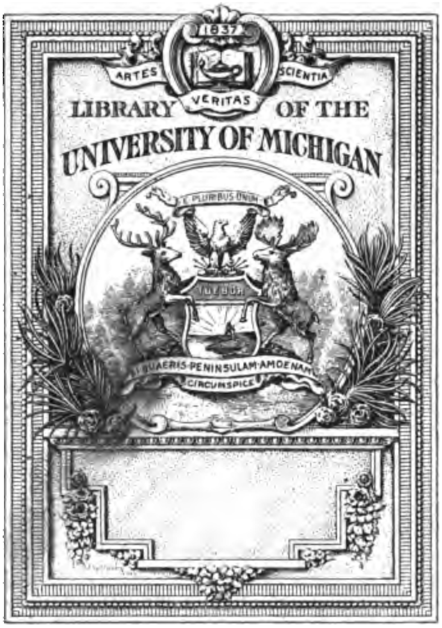
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BULLETIN No. 43. 212.

U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS.

LOSSES IN BOILING VEGETABLES

AND THE

COMPOSITION AND DIGESTIBILITY OF POTATOES AND EGGS.

BY

H. SNYDER, B. S., ALMAH J. FRISBY, M. D., AND A. P. BRYANT, M. S.

WASHINGTON:
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1897.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., May 15, 1897.

Sir: I have the honor to transmit herewith a report on the loss of nutrients in boiling potatoes, carrots, and cabbage, and the composition and digestibility of potatoes and eggs, by Prof. H. Snyder, Almah J. Frisby, M. D., and A. P. Bryant, M. S. These investigations constitute a part of the inquiries made with the funds appropriated by Congress "to enable the Secretary of Agriculture to investigate and report upon the nutritive value of the various articles and commodities used for human food," and were carried on under the supervision of Professor Atwater, special agent in charge of nutrition investigations, in accordance with instructions given by the Director of this Office.

The greater part of the food of man is prepared for use by cooking, yet the changes which various foods undergo during the process and the losses which are brought about by cooking have been little studied. This question has a wide practical application as well as scientific interest. In determining the nutritive value of various articles of food, digestibility is an important consideration. Perhaps no feature of the subject is more discussed. Nevertheless very few experiments with man to determine the digestibility of various foods have been made. Almost all information has been derived from artificial digestion experiments which approximate more or less closely digestion in the body. It is by no means certain that the two processes give the same results. Digestion experiments with man were believed to be necessary, and a diet in which potatoes were the chief ingredient was selected for experimental purposes.

Professor Snyder's work was carried on in the laboratory of the College of Agriculture of the University of Minnesota; that of Dr. Frisby and Mr. Bryant in the chemical laboratory of Wesleyan University, Middletown, Conn.

This report is respectfully submitted, with the recommendation that it be published as Bulletin No. 43 of this Office.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
LOSS OF NUTRIENTS IN BOILING POTATOES, CARROTS, AND CABBAGE. By H. SNYDER, B. S. 7
Introduction 7
The three principal classes of nutrients in foods 7
The effect of cooking on the nutrients of foods 8
Experiments with potatoes 9
Composition of potatoes 9
Cooking tests 11
Discussion of results 13
Conclusions 14
Experiments with carrots 15
Composition of carrots 15
Cooking tests 15
Conclusions 17
Experiments with cabbage 17
Composition of cabbage 17
Cooking tests 18
Conclusions 19
General summary 19
THE DIGESTIBILITY OF POTATOES AND EGGS. By H. SNYDER, B. S. 20
Introduction 20
Digestibility of boiled eggs in pepsin solution 20
Digestion experiment on man with a diet of potatoes, eggs, milk, and cream 21
Discussion of results 23
THE COMPOSITION OF DIFFERENT PARTS OF THE POTATO AND THE LOSS OF NUTRIENTS DURING THE PROCESS OF BOILING. By ALMAH J. FRISBY, M. D., and A. P. BRYANT, M. S. 25
Introduction 25
Composition of different parts of the potato 26
Sampling 26
The analyses 27
The protein factor 28
Amount of solid matter in the juice of the potato 29
Loss of nutrients in boiling 29
Conclusions 31

ILLUSTRATIONS.

Page.

FIG. 1. Cells of a raw potato with starch grains in natural condition........ 8

2. Cells of a partially cooked potato.. 8

3. Cells of a thoroughly boiled potato.................................... 9

4. The composition of the potato and the loss of nutrients when boiled with the skin removed.. 14

5. The composition of the carrot and the loss of nutrients when boiled.. 17

6. The composition of the cabbage and the loss of nutrients when boiled. 19

7. Transverse and longitudinal sections of the potato.................. 25

LOSSES IN BOILING VEGETABLES, AND THE COMPOSITION AND DIGESTIBILITY OF POTATOES AND EGGS.

LOSS OF NUTRIENTS IN BOILING POTATOES, CARROTS, AND CABBAGE.

By H. Snyder, B. S.,

Chemist, Minnesota Agricultural Experiment Station, and Professor of Agricultural Chemistry, College of Agriculture, University of Minnesota.

INTRODUCTION.

THE THREE PRINCIPAL CLASSES OF NUTRIENTS IN FOODS.

The nutritive ingredients of foods are commonly divided into three general classes, namely, nitrogenous substances to which the general term protein is applied, fats, and carbohydrates.

The nitrogenous substances.—The nitrogenous substances include (1) the albuminoids, of which egg albumen is a well-known example; (2) the so-called gelatinoids, of which gelatin may serve as a type; and (3) the amids; i. e., synthesis and cleavage products of various kinds.

The vegetable albuminoids are to a large extent different from those found in animal foods. They appear to be more variable in composition, and less is known concerning their chemical composition, structure, and digestibility.

The fats.—The amount of dry matter dissolved out of a substance by continuous treatment with ether is designated as fat. It forms a large part of animal foods, but in vegetable foods, with the exception of some seeds and nuts, the proportion is very small.

The carbohydrates.—This class includes the sugars, starches, woody fibers, cell walls, etc., of the vegetable foods. Carbohydrates are found in but few animal foods, with the exception of milk, and when present are in very small quantities. In vegetable foods, on the contrary, they form the major part of the nutritive matter. The principal constituent of vegetable carbohydrates is starch. The starch grains are usually inclosed in thin cells, the walls of which may be composed of more or less fibrous material.

The digestibility of the carbohydrates depends upon the proportion of sugar and starches to cell walls or fiber. The sugars are more easily digested than the starches, since the latter must be changed to sugar in the process of digestion before it can be assimilated by the body. Both the starches and the sugars, however, are probably completely digested, but the cell walls, the framework of the substance, are not so easily digested ; in fact, while 98 to 100 per cent of the starches and sugars may be digested, the digestibility of these cell walls, or fiber as it is called, may vary all the way from 30 to 70 per cent.

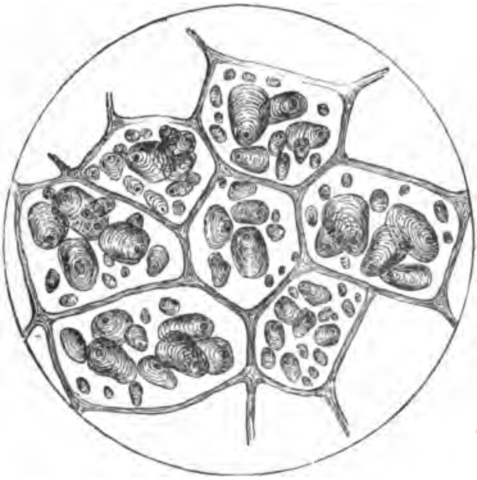

FIG. 1.—Cells of a raw potato with starch grains in natural condition.

THE EFFECT OF COOKING ON THE NUTRIENTS OF FOODS.

Some of the albuminoids are soluble in water, and nearly all in dilute saline solutions. Heating coagulates the albuminoids and renders them insoluble. Cooking, therefore, preserves albuminoids from loss. If meat is put into cold water and then brought to the boiling point more or less of the albuminoid material will be dissolved and some of the most expensive part of the food will be lost unless the soup is utilized also. If put directly into hot or boiling water the soluble albuminoids on the surface will be coagulated, and this loss will be largely prevented.[1] The same principle is probably applicable to vegetables also.

Besides rendering soluble albuminoids insoluble, cooking makes others of the nitrogenous substances more digestible, and in the case of meats loosens the fibers of connective tissue, rendering it tender and more palatable. Unless the degree of heat is great enough to cause scorching, fats are doubtless little affected by cooking.

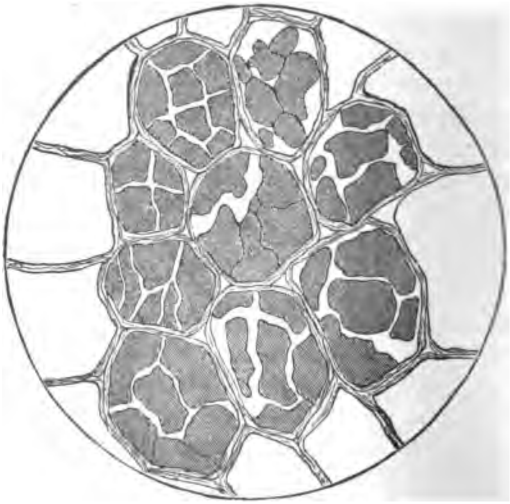

FIG. 2—Cells of a partially cooked potato.

The carbohydrates are much more easily digested in the cooked than in the raw state. In the raw food the sugars and starches are inclosed in cells. Very little of

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[1] U. S. Dept. Agr., Farmers' Bul. 34.

the cellulose of the cell walls is digested by man. The cell contents, therefore, are often excreted unchanged. Cooking bursts these cell walls, thus exposing the inclosed sugars and starches to the action of the digestive juices. The starch granules also swell up and burst on cooking, exposing more surface to be acted upon. Starch is to a slight extent changed to dextrin by dry heat, and possibly, also, by heating with water. Since the majority of vegetable foods, however, consist largely of starches and have very little sugar in them, the loss of carbohydrates would presumably not be very great during boiling.

The effect of boiling upon the cells of the potato is shown in figs. 1, 2, and 3.[1]

Several years ago Katherine Williams reported[2] an extended study of the composition of a number of cooked and a few raw vegetables. Ultimate and proximate analyses of the various vegetables were made and the fuel value determined. Many cooked vegetables have been analyzed in connection with the food investigations undertaken by this Department and by other investigators.

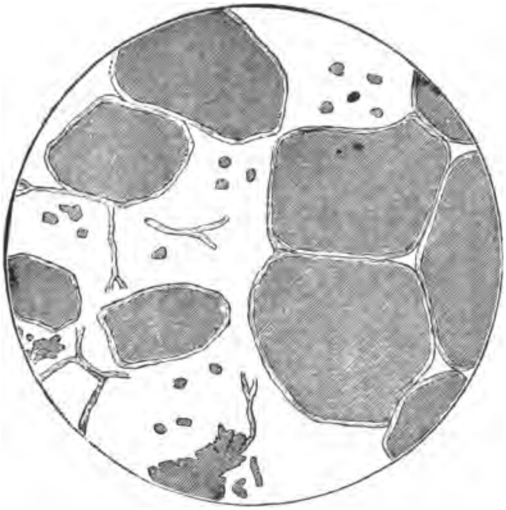

FIG. 3.—Cells of a thoroughly boiled potato.

Comparatively few attempts have been made to learn the changes which take place in vegetable foods on cooking, or the extent of these changes. As the water in which vegetables are boiled is usually thrown away, any matter which was in solution would be wasted. Experiments were therefore undertaken with potatoes, carrots, and cabbage for the purpose of studying the loss of nutrients when boiled, under a number of different conditions. These vegetables were selected as the best representatives of tubers, roots, and pot herbs.

EXPERIMENTS WITH POTATOES.

COMPOSITION OF POTATOES.

According to Lawes and Gilbert,[3] the composition of the flesh of the potato differs from that of the juice. Although the flesh contains 85 per cent of the total water-free substance, it contains but 15 per cent of

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 21, p. 88; from Märcker's Studien in der Spiritusfabrikation.

[2] Jour. Chem. Soc. [London], 61 (1892), p. 226.

[3] "On the growth of the potato," p. 26, Rothamsted Memoirs, vol. 6.

the nitrogen. The remainder, 85 per cent, is in the juice. Of this 49 per cent is in the form of albuminoid and 36 per cent in the form of nonalbuminoid nitrogen.

The proportion of albuminoid and nonalbuminoid nitrogen varies greatly according to different writers. E. Schulze and Barbieri [1] and E. Schulze and E. Eugster [2] give, as the result of five analyses, from 35 to 56 per cent of nonalbuminoid nitrogen. O. Kellner [3] gives 44 to 58 per cent of nonalbuminoid nitrogen, and A. Morgen [3] from 30 to 52 per cent, making 45 per cent as a fair average of the amount of nonalbuminoid nitrogen and 55 per cent for the amount of albuminoid nitrogen present in potatoes. In the experiments here reported the figures obtained were nearly the reverse of these latter, as the average of the two analyses made gave 40 per cent of albuminoid and 60 per cent of nonalbuminoid nitrogen (see also p. 29). It is evident that in boiling the loss of a considerable portion of this albuminoid nitrogen may occur.

There is also a possibility of loss of inorganic and organic salts during cooking. Probably about 85 per cent of the potash of the potato, as well as the larger part of the citric acid, is in the juice. The total amount of citric acid, however, is small. While potash salts and citrates have no real nutritive value, they appear to be of some considerable medicinal or tonic value and give "relish" to the food. No attempt was made to determine the loss of fat and fiber in boiling. It would be presumably, very small.

Three experiments on the effect of cooking on the composition of potatoes were made. In the first experiment (A) the skins were removed and the potatoes soaked three and five hours, respectively, and cooked in distilled water, which was cold at the beginning of the test. In the second experiment (B) the skins were removed and the potatoes, without previous soaking, were cooked in (1) distilled water (soft water), (2) alkaline water, (3) limewater (hard water), which was in each case cold at the beginning; in (4) distilled water, (5) alkaline water, and (6) limewater, which was in each case hot at the beginning of the test. In the third experiment (C) the potatoes were not peeled and were cooked without previous soaking in distilled, alkaline, and limewater, which was cold at the beginning of the test, and in distilled, alkaline, and limewater, which was hot at the beginning of the test.

About two bushels of potatoes of a uniform character were divided into lots of about a kilogram (2⅕ pounds) each. An analysis was made of the whole potato, including the skin. This was assumed to represent the composition of all the potatoes used in the experiments except those which were soaked before boiling. In this latter case half of each

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[1] Landw. Vers. Stat., 21 (1878), p. 63.

[2] Ibid., 27 (1882), p. 357.

[3] König, Chemie der menschlichen Nahrungs- und Genussmittel, 3d ed., II, p. 631.

of the peeled potatoes used in the experiment was taken as a sample and analyzed.

The methods of analysis used were substantially those adopted by the Association of Official Agricultural Chemists, and were as follows:

Nitrogen.—In order to ascertain the relative proportion of albuminoids and extractives or amids the nitrogen was determined, (1) as the total nitrogen by the Kjeldahl method, and (2) the albuminoid nitrogen by the Stutzer method. The results for albuminoid nitrogen are without doubt too low, as the copper proteid dissolved to a slight extent in the moderately warm solution when filtered and separated out on standing. If filtered when cold the filtration was so slow that fermentation, with a consequent loss of the copper proteid, would begin before the filtration was completed.

Starch.—Starch was determined by inversion with boiling hydrochloric acid and water and estimating the amount of copper in Fehling's solution precipitated by the resulting dextrin.

Fat, fiber, and ash.—These were determined in the usual way in the fresh material.

The accompanying table shows the composition of the potatoes used in these experiments, and gives also the composition as obtained by former analyses at the University of Minnesota,[1] the average of all American analyses,[2] and the average of European analyses.[3]

Composition of potatoes.

	Number of analyses.	Water.	Albuminoid nitrogen.	Total nitrogen.	Protein.	Fat.	Carbohydrates.			Ash.
							Fiber.	Starch.	Nitrogen-free extract. *a*	
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Used in Experiment A	1	78.0	0.15	0.35	2.2	....	....	....	....	0.9
Used in Eperiments B and C	1	77.2	.15	.40	2.5	0.1	0.2	16.4	19.3	.9
Average other Minnesota analyses	20	75.5	.20	.40	2.5	.1	.3	19.9	20.9	1.0
Average all American analyses	86	78.0	....	....	2.2	.1	....	....	18.8	.9
Average European analyses	178	75.0	*b* .19	.34	2.1	.1	.7	....	21.7	1.1

a 100 less the sum of the percentages of water, protein, fat, and ash.
b Calculated, allowing 45 per cent to be albuminoid.

COOKING TESTS.

The potatoes were boiled in a metal kettle over a gas flame at about the same rate as when cooked in the kitchen. The uncooked potatoes were weighed, and the water in which they were cooked was also weighed and analyzed. The total amounts of dry matter, albuminoid nitrogen, total nitrogen, starch, and ash that were removed in

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[1] Minnesota Sta. Bul. 42.

[2] From an unpublished compilation of analyses of American food products.

[3] König, Chemie der menschlichen Nahrungs- und Genussmittel, 3d ed., II, p. 626.

cooking 100 parts of fresh potatoes was then calculated. The results of each of the three experiments are given in the following table:

Loss of matter in cooking potatoes.

Method of preparation and cooking.	Weight of potatoes used.	Loss of matter in fresh potatoes.					Percentage loss of each constituent.				
		Dry matter.	Albuminoid nitrogen.	Total nitrogen.	Starch.	Ash.	Dry matter.	Albuminoid nitrogen.	Total nitrogen.	Starch.	Ash.
A. Skins removed; soaked before cooking.											
	Grams.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Soaked 3 hours; distilled water, cold at start	753	1.45	0.035	0.161	......	0.41	6.6	23.3	46.0	......	45.6
Soaked 5 hours; distilled water, cold at start	603	1.40	.040	.202	......	.28	6.4	26.7	57.7	......	31.1
Average	......	1.43	.038	.181	......	.35	6.5	25.0	51.8	......	38.3
B. Skins removed; not soaked.											
Distilled water, cold at start	943	.63	.007	.055	0.16	.18	2.8	4.7	13.8	1.0	19.6
Do	939	.74	.006	.080	.16	.15	3.2	4.0	20.0	1.0	16.3
Average	......	.68	.006	.068	.16	.16	3.0	4.3	16.9	1.0	17.9
Alkaline water, cold at start	1,165	.68	.016	.055	.15	.17	3.0	10.7	13.8	.9	18.5
Do	952	.67	.011	.061	.19	.17	2.9	7.3	16.7	1.2	18.5
Average	......	.67	.014	.065	.17	.17	2.9	9.0	15.2	1.0	18.5
Limewater, cold at start	907	.70	.011	.055	.14	.18	3.1	7.3	13.8	.9	19.6
Do	979	.79	.015	.067	.17	.19	3.5	10.0	16.7	1.0	20.6
Average	......	.75	.013	.061	.16	.19	3.3	9.0	15.3	1.0	20.1
Average of 6 tests starting with cold water	......	......	......	......	......	......	3.1	7.3	15.8	1.0	18.8
Distilled water, hot at start	939	.72	......	.033	.11	.17	3.2	......	8.2	.7	18.5
Do	1,052	.52	.004	.027	.10	.08	2.3	2.7	6.7	.6	8.7
Average	......	.62	.004	.025	.10	.13	2.8	2.7	7.5	.6	13.6
Alkaline water, hot at start	988	.71	.003	.033	.17	.19	3.1	2.0	8.3	1.0	20.7
Do	970	.80	.004	.041	.19	.22	3.5	2.7	10.2	1.2	23.9
Average	......	.76	.003	.037	.18	.21	3.3	2.3	9.2	1.1	22.3
Limewater, hot at start	952	1.15	.006	.024	.26	.15	5.1	4.0	6.0	1.6	16.3
Do	1,043	.78	.007	.038	.17	.19	3,4	4.7	9.5	1.0	20.7
Average	......	.96	.006	.031	.22	.17	4.2	4.3	7.8	1.3	18.5
Average of 6 tests starting with hot water	......	......	......	......	......	......	3.4	3.2	8.2	1.0	18.1
C. Skins not removed.											
Distilled water, cold at start	943	.14	Trace	.005	......	.03	.6	.3	1.2	......	3.3
Do	952	.11	Trace	.004	......	.07	.5	.1	1.0	......	7.6
Average	......	.13	Trace	.005	......	.05	.6	.2	1.1	......	5.4
Alkaline water, cold at start	988	.08	Trace	.004	......	.03	.4	.3	1.0	......	3.3
Do	1,034	.12	Trace	.005	......	.04	.5	.3	1.2	......	4.3
Average	......	.10	Trace	.005	......	.04	.5	.3	1.1	......	3.8
Limewater, cold at start	1,474	.04	.002	.003	......	.01	.2	1.3	.7	.1	1.1
Do	1,165	......	.002	.003	......	......	......	1.3	.8	.1	......
Average	......	.04	.002	.003	......	.01	.2	1.3	.8	.1	1.1
Average of 6 tests starting with cold water	......	......	......	......	......	......	.4	.6	1.0	.1	3.4

Loss of matter in cooking potatoes—Continued.

Method of preparation and cooking.	Weight of potatoes used.	Loss of matter in fresh potatoes.					Percentage loss of each constituent.				
		Dry matter.	Albuminoid nitrogen.	Total nitrogen.	Starch.	Ash.	Dry matter.	Albuminoid nitrogen.	Total nitrogen.	Starch.	Ash.
C. Skins not removed—Cont'd.	*Grams.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Distilled water, hot at start..	1,047	0.15	0.001	0.005	......	0.05	0.7	0.5	1.3	......	5.4
Do	1,075	.16	.001	.008	......	.04	.7	.5	2.0	......	4.4
Average	....	.16	.001	.006	......	.05	.7	.5	1.6	......	4.9
Alkaline water, hot at start..	1,229	.10	trace.	.003	......	.03	.4	.2	.8	......	3.2
Do	1,024	.09	trace.	.003	......	.02	.4	.2	.8	......	2.2
Average	....	.10	trace.	.003	......	.03	.4	.2	.8	......	2.7
Limewater, hot at start......	1,075	.04	.001	.002	0.01	.02	.2	.4	.5	0.1	2.2
Do	848	.06	.001	.003	.01	.02	.3	.5	.8	.1	2.2
Average	....	.05	.001	.002	.01	.02	.2	.5	.7	.1	2.2
Average of 6 tests starting with hot water...	....	......	......	......	......	......	.4	.4	1.0	.1	3.3

The weight of each ingredient removed divided by the total weight of the same ingredient in the fresh potatoes before cooking gives the percentage of loss of that substance. These figures are shown in the last five columns of the table. The same composition was assumed for the peeled potatoes used in Experiment B as for the whole potatoes used in Experiment C. This may not be strictly accurate, since it presupposes the uniform composition of all parts of the potato. As shown on page 27, there is a slight variation between the composition of the interior and the part peeled off, but this probably is not great enough to have a material effect upon the results obtained.

DISCUSSION OF RESULTS.

By reference to the table (p. 12) it will be seen that, as might be expected, the greatest loss occurs when the potatoes are peeled and soaked in cold water before boiling. In this case the loss of nitrogenous matter was from 46 to 58 per cent, depending upon the length of time they were soaked. Of the albuminoids 25 per cent and of the mineral matters 38 per cent were extracted by the water in which the potatoes were cooked. The water would ordinarily be thrown away and this material lost.

When the potatoes are peeled and put into cold water, and heated to boiling as soon as possible, the loss is much smaller, being about 16 per cent of the total nitrogenous matter (of which albuminoids form a trifle less than half) and about 19 per cent of the total mineral matter. When the potatoes are peeled and put directly into boiling water the loss of albuminoid and other nitrogenous matter is only about half that of the last case, but the amount of mineral matter is practically the same. The boiling water soon coagulates the albuminoids on the surface of the potato, rendering them insoluble. They fill the outer pores of the potato, rendering the inner juices less liable to loss, although not before a considerable amount of the salts or mineral matter has escaped. The relative amount of nonalbuminoid nitrogen lost is greater than when the potatoes are put into cold water at the start. There seemed to be but little difference as regards total nitrogenous matter, starch, and ash, whether distilled, alkaline, or limewater was used. The limewater, however, seemed to have a greater solvent action upon the albuminoids than did the distilled or alkaline waters. The solvent action of cold alkaline water was somewhat greater than that of distilled water. Inasmuch as the albuminoid material of the potato is a globulin,[1] and globulins are insoluble in pure water but soluble in saline water, this also is what would be expected. The salts in solution in the juice of the potato doubtless carry the globulin in solution to some extent, thus rendering a loss possible even in pure distilled water.

The loss in boiling peeled potatoes is shown in graphic form in figure 4.

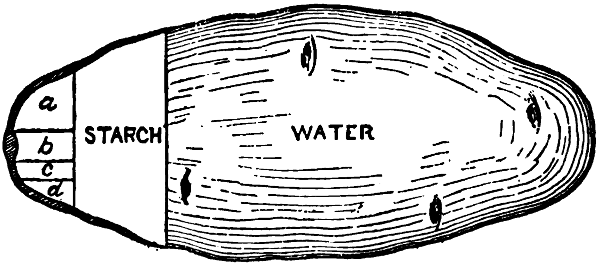

FIG. 4.—The composition of the potato and the loss of nutrients when boiled with the skin removed: *a*, fiber, pectose, fat, etc.; *b*, nonalbuminoid nitrogenous matter; *c*, albuminoid nitrogenous matter; *d*, mineral matter. The hatched portion represents the loss.

It will be seen from the table that when the potatoes are unpeeled the loss of matter is very inconsiderable, less than 1 per cent of the albuminoid matter, only 1 per cent of the total nitrogenous matter, hardly a trace of starch, and but a little over 3 per cent of the mineral matter being extracted. The different kinds of water had no effect except on mineral matter. This was removed to a greater extent by the distilled water than by the alkaline or limewater.

CONCLUSIONS.

The conclusions drawn from these experiments may be briefly summarized as follows:

(1) In order to obtain the highest food value, potatoes should not be peeled before cooking.

(2) When the potatoes are peeled before cooking, the least loss is sustained by putting them directly into hot water and boiling as rapidly as possible. Even then the loss is very considerable.

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[1] Osborne and Campbell, Connecticut State Sta. Rpt. 1895, p. 255 (E. S. R., 8, p. 371).

(3) If potatoes are peeled and soaked in cold water before boiling the loss of nutrients is very great, being one-fourth of all the albuminoid matter. In a bushel of potatoes the loss would be equivalent to a pound of sirloin steak.

EXPERIMENTS WITH CARROTS.

A series of experiments similar to those just described was undertaken with carrots. They were selected as fairly representative of the roots used for food. While in uncooked potatoes there is but a trace of sugar, such roots as beets, carrots, parsnips, etc., contain a considerable amount. This renders it probable at the outset that the loss in the cooking of carrots would be greater than in the cooking of potatoes.

COMPOSITION OF CARROTS.

Samples of the carrots used in the experiments were analyzed. The results of these analyses, as well as the average composition of carrots, including both American and European analyses, are shown in the following table:

Composition of carrots.

	Water.	Albuminoid nitrogen.	Total nitrogen.	Protein.	Fat.	Carbohydrates.					Ash.
						Cane sugar.	Fruit sugar.	Fiber.	Other carbohydrates.	Total carbohydrates. *a*	
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Carrots used in experiments ...	87.5	0.08	0.18	1.1	(*b*)	3.6	3.0	(*b*)	4.0	*c*10.6	0.8
Average 17 American analyses *d*	88.2	......	......	1.1	0.4	......	......	......	......	9.2	1.1
Average 35 European analyses *e*	86.8	......	......	1.2	.3	2.1	4.1	1.5	3.0	10.7	1.0

a 100 less the sum of the percentages of water, protein, fat, and ash.
b Not determined.
c Includes fat.
d U. S. Dept. Agr., Office of Experiment Stations Bul. 28.
e König, Chemie der menschlichen Nahrungs- und Genussmittel, 3d ed., II, p. 649.

Although carrots contain less nitrogen than potatoes, they seem to contain relatively more albuminoid nitrogen and therefore to furnish more matter available for building muscular tissue. In the carrots used in the following experiments, 44.4 per cent of the total nitrogen was in the albuminoid form.

COOKING TESTS.

In preparing carrots (sliced or whole) for the table they are put into either hot or cold water and boiled until they are soft enough to be easily pierced with a fork. The water in which the carrots have been boiled is usually drained off and thrown away. This water is colored yellow and has a very sweet taste, plainly indicating that some of the sugar has been extracted and lost.

In order to determine how much food value was lost in boiling carrots under various conditions, twelve trials were made in which limewater (hard water), alkaline water, and distilled water (soft water) were used. The carrots were prepared for cooking in the usual way by washing with a brush, scraping, drying quickly with a towel, and cutting into pieces. These pieces were wedge-shaped, usually about 4 inches long, and with three sides and a triangular base measuring about 1½ inches on a side. In some of the trials the pieces were cut smaller and in some larger in order to determine the effect of size on the loss of material. As in the experiments with potatoes, the water in which the carrots were cooked was hot at the beginning of the cooking period in some of the tests and cold in others. The carrots were boiled in a metal kettle over a gas flame under as nearly the usual conditions as possible The loss of matter in cooking 100 parts of fresh carrots and the percentages of each constituent lost in cooking under the various conditions are shown in the following table:

Loss of matter in cooking carrots.

Method of preparation and cooking.	Weight of carrots used.	Loss of matter in fresh carrots.					Percentage loss of each constituent.				
		Dry matter.	Albuminoid nitrogen.	Total nitrogen.	Sugar.	Ash.	Dry matter.	Albuminoid nitrogen.	Total nitrogen.	Sugar.	Ash.
A. Small pieces.	*Grams.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Alkaline water, hot at start..	358	3.68	0.006	0.063	2.18	0.31	29.4	7.5	35.0	33.0	41.3
Limewater, hot at start.......	349	3.81	.008	.078	1.14	.37	30.5	10.0	43.3	17.3	49.4
Distilled water, cold at start..	399	3.55	.009	.064	......	.31	28.4	11.3	35.6	......	41.3
Limewater, cold at start......	476	3.93	.010	.101	1.82	.43	31.4	12.5	56.1	27.6	57.3
Average	....	3.74	.008	.077	1.71	.36	29.9	10.3	42.5	26.0	47.3
B. Medium-sized pieces.											
Distilled water, hot at start..	494	2.93	.006	.048	......	.12	23.4	7.5	26.7	......	16.0
Do	480	3.70	.006	.047	......	.30	29.6	7.5	26.1	......	40.0
Limewater, hot at start.......	444	2.72	.005	.055	......	.34	21.7	6.3	30.6	......	45.3
Alkaline water, hot at start..	353	2.52	.006	.045	1.58	.33	20.2	7.5	25.0	23.9	44.0
Distilled water, cold at start..	580	2.68	.005	.050	......	.15	21.4	6.2	27.8	......	20.0
Alkaline water, cold at start..	503	2.47	.005	.047	......	.29	19.8	6.3	26.1	......	38.7
Do	403	3.61	.003	.055	1.92	.43	28.9	3.7	30.6	29.1	37.3
Average	....	2.95	.005	.050	1.75	.28	23.5	6.4	27.5	26.5	37.3
C. Large pieces.											
Limewater, cold at start......	499	2.52	.004	.036	1.02	.22	20.2	5.0	20.0	15.5	29.3

As will be seen, the character of the water makes little apparent difference in the amount of nutrients lost when carrots are boiled. The loss depends almost wholly upon the size of the pieces. The loss of mineral matter is large, being nearly one-half of the total amount in the case of the small pieces, and nearly one-third of the total when the pieces were large. The loss of nitrogenous matter and sugar is also very large. With small pieces about 40 per cent of the total nitrogen and 26 per cent of the total sugar is lost, or about 1 pound of sugar in a bushel of carrots. With medium-sized pieces the loss of nitrogen is 27 per cent and of sugar 26 per cent. With large pieces the loss of nitrogen is 20 per cent and of sugar 15 per cent. This latter loss is equivalent to over half a pound of sugar in a bushel of carrots. Of the total nutrients 30 per cent is lost from the small pieces, 24 per cent from the medium, and 20 per cent from the large pieces. In other words, as ordinarily cooked carrots lose one-quarter of their nutritive value. Figure 5 shows these losses graphically.

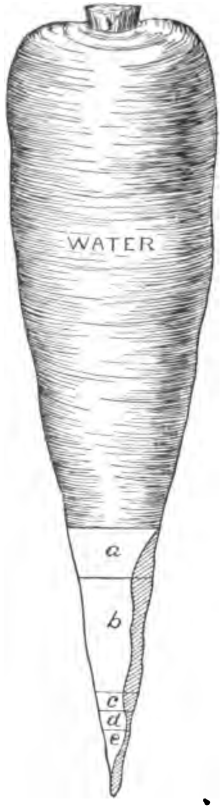

Fig. 5.—The composition of the carrot and the loss of nutrients when boiled: *a*, fiber, starch, fat, etc.; *b*, sugar; *c*, nonalbuminoid nitrogenous matter; *d*, albuminoid nitrogenous matter; *e*, mineral matter. The hatched portion represents the loss when medium-sized pieces were boiled.

CONCLUSIONS.

These trials suggest that in order to retain the greatest amount of nutrients in the cooking of carrots (1) the pieces should be large rather than small; (2) the boiling should be rapid in order to give less time for the solvent action of the water to act upon the food ingredients; (3) as little water as possible should be used; and (4) if the matter extracted be used as food along with the carrots, instead of being thrown away, the loss of 20 to 30 per cent, or even more, of the total food value may be prevented.

EXPERIMENTS WITH CABBAGE.

Experiments analogous to those with potatoes and carrots were made with cabbage to determine the loss of food material during the process of preparation for the table.

Cabbage may be taken as representing the class of pot herbs in which the leaves are the edible portion. It exposes more surface to the action of the water than do tubers or roots.

COMPOSITION OF CABBAGE.

The composition of the cabbage analyzed in connection with these experiments, as well as the average of American analyses of cabbage, is as follows:

Composition of cabbage.

	Water.	Albuminoid nitrogen.	Total nitrogen.	Protein.	Fat.	Carbohydrates.	Ash.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Cabbage used in these experiments	92.5	0.11	0.18	1.1	0.5	0.7	0.7
Average of 7 American analyses [a]	90.3	....	....	2.1	.4	5.8	1.4

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 28.

It will be noticed especially that in cabbage there is, relatively, much more albuminoid material than in either potatoes or carrots, the albuminoid nitrogen amounting to 61 per cent of the total nitrogen.

COOKING TESTS.

The plan of the experiments was the same as that followed in the experiments with potatoes and carrots. In each trial half of a solid fair-sized cabbage was used. The cabbage was boiled in a metal kettle over a gas flame at about the same rate as on an ordinary cook stove. The following table shows the results obtained by the different methods of cooking:

Loss of matter in cooking cabbage.

Method of cooking.	Weight of cabbage used.	Loss of matter in fresh cabbage.					Percentage loss of each constituent.				
		Dry matter.	Albuminoid nitrogen.	Total nitrogen.	Fat and carbohydrates.	Ash.	Dry matter.	Albuminoid nitrogen.	Total nitrogen.	Fat and carbohydrates.	Ash.
	Grams.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Distilled water, cold at start.	471.7	2.48	0.003	0.062	1.76	0.33	33.2	2.7	34.4	31.1	47.1
Do	390.1	2.69	.009	.055	2.01	.34	36.0	8.2	30.6	35.6	48.6
Average	......	2.58	.006	.058	1.88	.34	34.6	5.5	32.5	33.3	47.8
Alkaline water, cold at start.	326.6	3.17	.009	.081	2.39	.27	42.4	8.2	45.0	42.3	38.6
Do	317.5	3.08	.013	.065	2.37	.30	41.2	11.8	36.1	42.0	42.8
Average	......	3.12	.011	.073	2.38	.29	41.8	10.0	40.6	42.1	40.7
Limewater, cold at start	331.1	3.17	.005	.087	2.23	.40	42.4	4.6	48.3	39.5	57.1
Do	240.4	3.05	......	.078	2.20	.36	40.8	......	43.3	38.9	51.4
Average	......	3.11	.005	.083	2.22	.38	41.6	4.6	45.8	39.2	54.2
Average of 6 tests in cold water	......	......	......	......	......	......	39.3	6.7	39.6	38.2	47.6
Distilled water, hot at start	435.5	2.17	.005	.060	1.56	.23	29.0	4.6	33.3	27.6	32.9
Do	367.4	2.22	.008	.054	1.65	.23	29.7	7.3	30.0	29.2	32.9
Average	......	2.20	.007	.057	1.60	.23	29.4	6.0	31.7	28.4	32.9
Alkaline water, hot at start	317.5	2.70	.008	.057	2.13	.21	36.1	7.3	31.7	37.7	30.0
Do	263.1	2.79	.013	.076	2.04	.27	37.3	11.8	42.2	36.1	38.6
Average	......	2.75	.011	.067	2.09	.24	36.7	9.6	37.0	36.9	34.3
Limewater, hot at start	330.7	3.05	.006	.071	2.21	.40	40.8	5.5	39.4	39.1	57.1
Do	689.5	2.82	......	.068	2.04	.35	37.7	......	37.8	36.1	50.0
Average	......	2.94	.006	.070	2.12	.38	39.2	5.5	38.6	37.6	53.5
Average of 6 tests in hot water	......	......	......	......	......	......	35.1	7.0	35.8	34.3	40.2

Even under the most favorable conditions the loss during the cooking of cabbage is very great, being 30 per cent of the total dry matter when distilled water is used and as high as 40 per cent when limewater is used. In the latter case over one-half of the mineral matter and over one third each of the carbohydrates and nitrogenous matter are dissolved out during the process of cooking. The albuminoid matter seems to be less soluble than any other of the substances present, there being but from 5 to 10 per cent of loss. Since albuminoids make up 61 per cent of the total nitrogenous substances, it follows that with a loss of from 35 to 40 per cent of the total nitrogenous matter nearly all of the nonalbuminoid nitrogenous compounds must be dissolved out in the water in which the cabbage is cooked. It will be noticed that the loss of albuminoid nitrogen was much greater where alkaline water was used than with either distilled or limewater. The average loss in the cooking of cabbage is shown graphically in fig. 6.

CONCLUSIONS.

The kind of water used has more effect on the loss of nutrients in cooking cabbage than the temperature of the water at which the cooking is started. In any case the loss is large. In 100 pounds of uncooked cabbage there are but 7½ pounds of dry matter, and of this dry matter from 2¼ to 3 pounds are lost in the process of cooking. This loss seems to be unavoidable unless the cabbage is cooked in such a manner that the water in which it is boiled is also used. This is frequently the case when cabbage is cooked with corned beef.

FIG. 6.—The composition of the cabbage and the loss of nutrients when boiled: *a*, starch, sugar, fiber, fat, etc.; *b*, nonalbuminoid nitrogenous matter; *c*, albuminoid nitrogenous matter; *d*, mineral matter. The hatched portion represents the loss.

GENERAL SUMMARY.

The losses which occur in cooking potatoes, carrots, and cabbage vary with the different methods of boiling followed, being quite considerable in some cases. These losses must be taken into account in computing dietaries and made good by adding other materials to supply the nutrients lost. While the loss is not so great as to render it imperative that people in comfortable circumstances should abandon methods of preparing these foods which they consider make them most palatable, there are very large numbers who can not afford to permit even the comparatively small waste of food observed in these experiments.

The purpose of experiments, such as those here reported, is to learn what actually takes place in the process of preparing food by the common methods. Those having charge of the preparation of food must determine how far it is desirable under individual circumstances to apply the information obtained.

THE DIGESTIBILITY OF POTATOES AND EGGS.

By H. Snyder, B. S.,

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INTRODUCTION.

There seems to be a very wide difference of opinion regarding the digestibility of the potato, some considering it a very easily digested food and others a food digested with some difficulty. The information on which such opinions are based is comparatively limited. Our knowledge concerning the digestibility of food is quite largely based on artificial digestion experiments. The number of experiments made with man is comparatively small. An experiment with man on the digestibility of potatoes was made by Rubner and reported some years ago.[1]

More work of this nature seemed desirable, therefore an experiment was undertaken with a healthy man in which potatoes formed the principal article of diet. Potatoes being almost entirely a farinaceous food, it was necessary to have some easily digested albuminoids in the dietary and also some fat, since previous digestion experiments in this laboratory have indicated that in order to obtain normal digestion it is necessary to use a well-balanced ration supplying a sufficient amount of nitrogenous material for replenishing the waste tissues of the body. To furnish this nitrogenous matter and fat hard-boiled eggs were added. Upon trial the diet of potatoes and eggs proved an unnatural and distasteful one to the subject and it was found necessary to add some milk and a little cream to the dietary in order to make it well balanced and palatable.

The digestibility of the eggs was first determined by the Stutzer method of artificial digestion, to learn something of the effect of boiling for various periods. Such knowledge was considered essential in the interpretation of the results of the experiments with man. The digestibility of the milk and cream were assumed as described beyond.

DIGESTIBILITY OF BOILED EGGS IN PEPSIN SOLUTION.

Five experiments were made to determine the digestibility of eggs cooked under different conditions. A pepsin solution was prepared consisting of 1.1 parts of pepsin and 7.5 parts of hydrochloric acid in

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[1] Ztschr. Biol., 1879, p. 147. U. S. Dept. Agr., Office of Experiment Stations Bul. 21, p. 60.

500 parts of water. This solution dissolved 50 parts of hard-boiled egg albumen in six and one-half hours at a temperature of from 38° to 40° C.

Eggs were cooked for 3 minutes at 100° C., giving a "soft-boiled" egg, and for 5 minutes and 20 minutes at the same temperature. One egg boiled 3 minutes and digested for 5 hours in about 200 cc. of pepsin solution as prepared above, compared with one boiled 20 minutes and treated in the same way, showed 8.3 per cent undigested nitrogen in the former, against 4.1 per cent undigested nitrogen in the latter. Under similar treatment the egg boiled 5 minutes gave 3.9 per cent undigested nitrogen.

Another trial was then made, in which the eggs were cooked for periods of 5 and 10 minutes in water at 82.2° C. (180° F.) In both of these cases the nitrogen was entirely digested in 5 hours. The results are given in the following table:

Result of digesting boiled eggs 5 hours in pepsin solution.

No. of experiment.	Length of time cooked.	Temperature at which cooked.	Weight egg used (without shell).	Total nitrogen in fresh eggs.	Total undigested nitrogen.	Total nitrogen digested.	Pepsin solution used.
	Minutes.	*Deg. F.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*	*Cc.*
1	5	180	39.34	.944	....	100.0	197
2	10	180	47.02	1.128	....	100.0	235
3	3	212	38.67	.929	0.0768	91.7	193
4	5	212	43.80	1.050	.0408	96.1	219
5	20	212	40.64	.960	.0408	95.8	203

From the above it seems probable that while the method of cooking has some effect upon the rate of digestibility it does not materially affect the total digestibility. These results agree quite closely with those obtained by Rubner.[1] In an experiment with man he found that 97.1 per cent of the nitrogen of hard-boiled eggs was digested.

DIGESTION EXPERIMENT ON MAN WITH A DIET OF POTATOES, EGGS, MILK, AND CREAM.

The subject of the digestion experiment was a healthy man, 22 years old. He was a laboratory assistant, and his work did not demand a great amount of muscular exercise. The experiment began with dinner May 14, 1896, and ended after dinner May 18, covering 13 meals, or 4⅓ days. The weight of the subject (without clothing) at the beginning of the experiment was 62.5 kilograms (137½ pounds) and at the end 62.6 kilograms (137¾ pounds).

The daily dietary as finally adopted consisted of 1587.6 grams (3½ pounds) of potatoes, 8 eggs, 710 cubic centimeters (1½ pints) of milk, and 237 cubic centimeters (½ pint) of cream. The latter was necessary in order to supply fat to raise the fuel value of the food to the desired

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[1] Ztschr. Biol., 1879, p. 128. U. S. Dept. Agr., Office of Experiment Stations Bul. 21, p. 61.

point. The approximate amounts and the composition of each food consumed per day are shown in the following table:

Amount and composition of preliminary daily diet.

	Solid matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value.
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
Potatoes (1,587 grams)	362.88	6.35	39.92	0.45	299.38	14.51	1,394
Eggs (8, hard boiled)	113.40	8.16	50.80	48.99	....	4.08	664
Milk (710 cubic centimeters)	90.72	4.08	25.40	27.22	30.39	4.98	482
Cream (237 cubic centimeters)	40.82	.91	5.44	34.02	3.63	1.36	355
Total	607.82	19.50	121.56	110.68	333.40	24.93	2,895

This diet was given for three days before the experiment began in order that the body might get into equilibrium with it.

After breakfast on the day the experiment commenced and after dinner on the day it closed some charcoal in gelatin capsules was taken, in order to identify the feces belonging to the food of the experiment proper. The fresh feces weighed on an average 204 grams per day and the urine 1,108 grams. The food, urine, and feces were analyzed. The composition of the total food eaten and of the total feces, together with the nutrients contained in the food eaten and lost in the feces and the percentage of each nutrient digested, are shown in the following tables:

Weight and composition of food eaten and of feces for four and one-third days.

	Weight.	Total organic matter.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per gram, calculated.
	Grams.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Potatoes	6,380	28.85	9.50	0.08	19.27	0.90	0.935
Eggs	1,800	23.86	12.63	11.23	....	.86	1.739
Milk	2,722	12.27	3.25	4.01	5.01	.75	.757
Cream	908	17.41	1.69	14.00	1.72	.60	1.465
Feces	*a* 206	82.33	26.56	14.30	*b* 41.47	16.27	4.490

a Water-free substance.

b One and four-tenths per cent is allowed for biliary products. Carbohydrates = 100.00 − (Protein + Fat + Ash + 1.40).

Weights and fuel values of nutrients in food eaten and in feces for four and one-third days; and weights, fuel value, and percentages of nutrients digested.

	Total organic matter.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value.
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
Potatoes	1,394.0	159.5	5.1	1,229.4	57.4	5,965
Eggs	429.5	227.4	202.1	....	16.5	3,130
Milk	334.0	88.5	109.1	136.4	20.4	2,060
Cream	158.0	15.3	127.1	15.6	5.4	1,330
Total eggs, milk, and cream	921.5	331.2	438.3	152.0	42.3	6,520
Total, from whole food	2,315.5	490.7	443.4	1,381.4	99.7	12,485
Fuel value of urea (435.9 × 0.87)	....	....	....	....	....	379
Net fuel value of food eaten	....	....	....	....	....	12,106
Feces, i. e., undigested residue	169.9	54.8	29.5	85.6	33.6	926
Amount digested in whole food	2,145.6	435.9	413.9	1,295.8	66.1	11,180
Amount eggs, milk, and cream digested	882.1	321.2	....	152.0	....	6,192
Amount potatoes digested	1,263.5	114.7	....	1,143.8	....	4,988
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Per cent digested of whole food	92.7	88.8	93.3	93.8	(*a*)	89.5
Per cent digested of potatoes	90.6	71.9	....	93.0	....	83.6

a An unknown amount of salt was eaten, which renders the amount of mineral matter digested somewhat doubtful.

In calculating the amount of nutrients furnished by the eggs, milk, and cream that were digested, it is assumed that 97 per cent of the protein and all of the carbohydrates (chiefly milk sugar) in these foods were digested. Inasmuch as the amount of fat in the potato is so extremely small, no attempt was made to calculate its digestibility. The figures for the digestibility of the whole food (93 per cent) practically represent the digestibility of the fat in the eggs, milk, and cream. The amount of nutrients digested in the eggs, milk, and cream deducted from the total digested nutrients gives the nutrients digested from the potato. The percentages digested were calculated from these amounts. In calculating the fuel value 1 gram of protein is assumed to yield 5.5 calories, 1 gram of fat 9.3 calories, and 1 gram of carbohydrates 4.1 calories. Nitrogenous matter is not as completely oxidized in the body as when burned in the air,[1] since it is largely excreted in the form of urea. Urea contains some energy, which is, however, unavailable to the body. Briefly, the fuel value of urea is calculated as follows:[2]

$$\frac{\text{M protein}}{6.25} \times 2.143 \times 2.53 = \text{fuel value of urea.}$$

This may be reduced to the simpler form, M protein × 0.87=fuel value of urea.

More or less salt was eaten of which no account was made, therefore the digestibility of the ash is not calculated. It is of comparatively little importance, since to some extent at least the soluble mineral matters, e. g., salt, pass directly to the kidneys, from which they may be secreted within a few hours after being taken into the stomach.

DISCUSSION OF RESULTS.

From the results of this experiment it would seem that while the nitrogenous matter is not very completely digested, the digestibility of the carbohydrates is quite high. Since the potato consists very largely of carbohydrates, it may be regarded, at least in the case of the person here experimented with, as a food which is well digested. The results obtained in this experiment agree very closely with those obtained by Rubner (see p. 21), as will be seen by the following comparison:

The digestibility of potatoes as determined by American and European investigators.

	Protein digested.	Carbohydrates digested.
	Per cent.	*Per cent.*
The author's experiment	71.9	93.0
Rubner's experiment	67.8	92.4

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[1] U. S. Dept. Agr., Office of Experiment Stations Bul. 21, p. 103.

[2] Connecticut Storrs Sta. Rpt. 1894, p. 125.

The nitrogen balance.—The urine was collected during the period covered by the digestion experiment, and the total of solids, nitrogen, and ash in it determined. In this way a balance of income and outgo of nitrogen could be obtained and the resultant gain or loss of protein calculated. The amount of urine excreted during the period covered by the experiment was 4,800 grams. It contained 6.18 per cent of water-free substance, 1.42 per cent of nitrogen, and 1.63 per cent of ash. The gain or loss of nitrogen and the calculated gain or loss of protein per day are shown in the following table:

Balance of income and outgo of nitrogen and gain of protein.

	Nitrogen in food.	Nitrogen in feces.	Nitrogen digested.	Nitrogen in urine.	Nitrogen gained.	Protein gained.
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Quantities for whole period (4⅓ days)...	78.51	8.77	69.74	68.16	1.58	9.88
Quantities per day......................	18.14	2.03	16.11	15.74	.37	2.31

During the experiment the subject gained 9.88 grams (one-third of an ounce) of protein. Assuming that muscle contained 23 per cent of protein, the subject gained 43 grams of muscle, or about 1½ ounces.

THE COMPOSITION OF DIFFERENT PARTS OF THE POTATO AND THE LOSS OF NUTRIENTS DURING THE PROCESS OF BOILING.

By Almah J. Frisby, M. D., and A. P. Bryant, M. S.

INTRODUCTION.

The potato is composed of three parts, which may for convenience be termed outer skin, inner skin, and flesh. The outer or true skin is dry in appearance, usually grayish brown in color and corresponds to the bark of the rest of the plant. The portion lying immediately beneath the skin is slightly colored, containing whatever coloring matter may be present in the potato, and is the part which turns green on continued exposure to the sunlight, giving a strong unpleasant taste to the potato. This portion has some resemblance to the skin in general appearance, and is usually removed with the skin in preparing potatoes for the table. Its true name is the fibro-vascular layer, but it is also sometimes designated as the herbaceous or cortical layer, subcutaneous portion, and inner skin (see fig. 7). The main bulk of the potato is composed

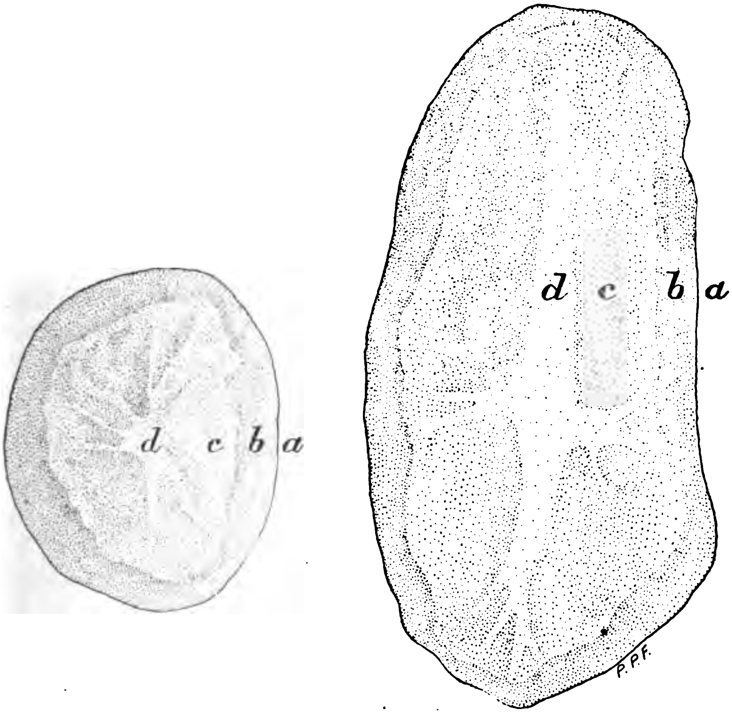

Fig. 7.—Transverse and longitudinal sections of the potato (after Coudon and Bussard): *a*. skin; *b*, cortical layer; *c*, outer medullary layer; *d*, inner medullary layer.

filled with starch grains and a little nitrogenous matter, and may be designated as the flesh of the potato.

[Shortly after the completion of the present bulletin an extended study of potatoes was reported by H. Coudon and L. Bussard.[1] The authors investigated the botanical structure of a large number of varieties of potatoes and determined the relative composition of large, medium, and small potatoes and of the different parts of the tubers. The taste and culinary properties of a number of standard varieties were also investigated. The potatoes were cooked in several ways. Among the conclusions reached by the authors were the following: In judging the value of a variety of potatoes analyses should be made of a number of entire tubers. The culinary value of the potato is directly proportional to its nitrogen content and inversely proportional to its starch content. The different varieties of potatoes were found to vary greatly in their resistance to boiling, some retaining their form completely, while others were almost entirely disintegrated. In the author's opinion the resistance to boiling did not depend upon the content of pectin or starch, but seemed to depend principally upon the relative proportion of albuminoids present. No definite relation was observed between chemical composition and early maturity. Generally speaking, the early varieties contained more water and nitrogenous material and less starch than the late varieties. The number of exceptions was, however, large.]

In order to ascertain to some extent the variation in composition of the different parts of the tuber a quantity of smooth potatoes of average size was obtained and analyses of the different parts made. The variety selected was that known as the "White Star."

COMPOSITION OF DIFFERENT PARTS OF THE POTATO.

SAMPLING.

Twelve medium-sized potatoes of known weight were taken. The skin was carefully removed by scraping with a knife and the skin and potatoes weighed. The sum of the weights of the scraped potatoes and of the skins did not equal the weight of the potatoes at the start. More or less water had evaporated from the moist surfaces. It was assumed that half of the loss came from the skins and half from the smooth surface of the scraped potatoes, inasmuch as the amount of surface freshly exposed to the air was the same in the two portions. The inner skin of the potatoes, or fibro-vascular layer, was next removed by scraping, care being taken to include as little flesh of the potato as possible. The amount removed by this operation was weighed as before and the loss of water during the process divided equally between the part removed and the part remaining, i. e., the flesh. The three portions were dried at 100° C. and this partially dried material

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[1] Ann. Sci. Agron., 1897, I, No. 2, p. 250.

of cells was analyzed. The weights of the different parts and their proportion of the whole potato were as follows:

Proportions of different parts of the potato.

	Weight in grams.	Per cent of whole.
Twelve unpeeled potatoes	1,633	100.0
Outer, or true, skin	41	2.5
Inner skin or fibro-vascular layer *a*	139	8.5
Flesh	1,453	89.0

a Including a small amount of flesh.

THE ANALYSES.

Water, nitrogen, fat, and ash were determined by the usual methods. Crude fiber was determined in the fibro-vascular layer and the flesh, but there was so little of the skin left after making the other determinations that the estimation of fiber could not be made. It would, however, presumably be quite high.

The nitrogen of the potato is not all in the form of true albuminoids or proteids, but nearly half is in the form of amido compounds, including, principally, asparagin.[1] Inasmuch as the amount of nitrogenous material in the potato is small, and the amido compounds can neither build tissue nor repair waste as do the albuminoids, the nutritive value of the nitrogenous substance (protein) of the potato is very small. In the experiments here reported the albuminoid nitrogen was determined by Stutzer's method.

The composition of different parts and the calculated composition of whole potatoes here analyzed as compared with results of other American and European analyses are shown in the following table:

Composition of the whole potato and its different parts.

	Water.	Nitrogen.		Pro-tein.	Fat.	Carbohydrates.		Ash.
		Albuminoid.	Total.			Nitrogen-free extract.	Fiber.	
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Outer, or true, skin	80.1	0.25	0.43	2.7	0.8	14.6		1.8
Inner skin or fibro-vascular layer	83.2	.24	.36	2.3	.1	12.6	0.7	1.1
Flesh	81.1	.18	.32	2.0	.1	15.7	.3	.8
Calculated composition of whole potato	81.3	.19	.32	2.0	.1	15.7		.9
Average of 86 American analyses *a*	78.0	....	.35	2.2	.1	18.8		.9
Average of 178 European analyses *b*	75.0	.19	.34	2.1	.1	21.0	.7	1.1

a From an unpublished compilation of analyses of American food products.
b König, Chemie der Nahrungs- und Genussmittel, 3d ed., II, p. 626.

Although of fine appearance, the potatoes used in the present experiment contained an unusually small amount of dry matter and a large proportion of water, as will be seen by comparing their chemical com-

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[1] Schulze, Barbieri, and Eugster, Land. Vers. Stat., 21 (1878), p. 63; 27 (1882), p. 357. See also König, Chemie der menschlichen Nahrungs- und Genussmittel, 3d ed., II, p. 631.

position with that of average potatoes. Whether this was due to the variety or to the year is a matter of doubt. The skin, although apparently very dry, contained nearly as large a percentage of water as the rest of the potato. The portion immediately under the true skin, i. e., the fibro-vascular layer, contained the greatest amount of water. Payen[1] states that the epidermis and the herbaceous portion immediately below it contain little or no starch deposit. The above results seem to be in accord with this, though no estimation of starch itself was made. It will be noticed that the skin contains about 40 per cent more albuminoid nitrogen than the flesh, and more than twice the amount of mineral matter (ash). One of the most noticeable differences is the relatively large amount of ether extract in the skin—nearly 1 per cent. This had much the appearance of wax, and had an odor slightly resembling that of beeswax.

THE PROTEIN FACTOR.

The protein was determined as usual by multiplying the total nitrogen by the factor 6.25. This factor is based on the assumption that there is on the average 16 per cent of nitrogen in protein. In the case of potatoes the results thus obtained are considerably too large. In the first place, the nonalbuminoid compounds have a much larger proportion of nitrogen than do the albuminoids, and consequently should be obtained by the use of a much smaller factor than 6.25. Besides this, the albuminoids themselves contain slightly more than 16 per cent of nitrogen. Osborne and Campbell[2] have investigated the proteid of the potato, which they propose to call "tuberin," and find that it contains 16.24 per cent of nitrogen.

For the present purpose it will be convenient to assume that all the nonalbuminoid nitrogen of the potato occurs in forms more or less similar to asparagin. Asparagin contains 21.21 per cent of nitrogen. The average amount of albuminoid nitrogen in potatoes is 56 per cent of the whole, which is the same proportion as was found in the flesh of the potatoes used in these experiments. Assuming 56 per cent of the nitrogen of the potato to belong to albuminoid nitrogenous matter (tuberin) and the remaining 44 per cent of the nitrogen to belong to nonalbuminoid nitrogenous matter (asparagin), there will be an average of 18.42 per cent of nitrogen in the nitrogenous substance of the potato. This corresponds to the factor 5.43.

In round numbers, therefore, 5.5 may be taken as the factor by which the total nitrogen of the potato should be multiplied in order to obtain the total nitrogenous matter or protein. While the change made by using this instead of the ordinary factor 6.25 for calculating the protein is slight, it would amount to about a gram of protein per day in the case of a person eating 340 grams (¾ pound) of potatoes daily. The

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[1] Substances alimentaires, p. 305.

[2] Connecticut State Sta. Rpt. 1895, p. 255 (E. S. R., 8, p. 371).

difference in composition as computed by using the factor 5.5 for calculating protein instead of the factor 6.25 is shown in the following table:

Comparison of the composition of the potato when the factor 5.5 is used instead of the factor 6.25 in calculating protein.

	Water.	Protein.		Fat.	Carbohydrates by difference.[a]		Ash.
		Nitrogen × 5.5.	Nitrogen × 6.25.		When protein = N × 5.5.	When protein = N × 6.25.	
	Per ct.	*Per cent.*	*Per cent.*	*Per ct.*	*Per cent.*	*Per cent.*	*Per ct.*
Outer, or true, skin	80.1	2.4	2.7	0.8	14.9	14.6	1.8
Inner skin or fibro-vascular layer	83.2	2.0	2.3	.1	13.6	13.3	1.1
Flesh	81.1	1.8	2.0	.1	16.2	16.0	.8
Calculated composition of whole potato	81.3	1.8	2.0	.1	15.9	15.7	.9
Average of 86 American analyses	78.0	1.9	2.2	.1	19.1	18.8	.9

[a] 100 less the sum of the percentages of water, protein, fat, and ash.

AMOUNT OF SOLID MATTER IN THE JUICE OF THE POTATO.

When we consider the amount of water in the potato, it is to be expected that a considerable portion of the ingredients may be in solution. If a potato be grated and the juice pressed through a linen cloth a large amount of dark-colored liquid is obtained having an acid character. This acidity is commonly said to be chiefly due to citric acid with more or less tartaric and succinic acids. The mineral water is very largely in the form of potash salts, soluble in water. The asparagin present is also soluble in water, and the tuberin more or less soluble in the acid. The following table shows the percentages of the different substances found in the juice of the potato and in the solid matter:

Distribution of material in the solid matter and juice of the potato.[a]

	Dry matter.	Nitrogen.			Ash.
		Albuminoid.	Nonalbuminoid.	Albuminoid + nonalbuminoid.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
In solid matter	85	15	0	15	15
In juice	15	49	36	85	85
Total	100	64	36	100	100

[a] Lawes and Gilbert, On the Growth of the Potato, p. 26, Rothamsted Memoirs, vol. 6.

LOSS OF NUTRIENTS IN BOILING.

Since 85 per cent of the nitrogenous matter and 85 per cent of the mineral matter are in a state of solution in the potato, it would seem quite probable that there might be a considerable loss of these substances during the process of preparing potatoes for the table. Experiments were therefore made to investigate this loss and determine its amount. Four trials were made, (1) with the skins removed, the peeled potatoes being put in cold water, which was heated at once over a moderate flame; (2) with the skins removed, the peeled potatoes placed directly in boiling water; (3) with the skins on, the potatoes being put in cold water, which was heated as in the first case; and (4) with the skins on, the potatoes being placed directly in hot water as in the second case. Six medium-sized potatoes were used for each trial. They were boiled in one liter of distilled water in an aluminum kettle until they were easily pierced with a fork. The kettle was then removed from the fire, the water poured off, and the potatoes rinsed with distilled water. It was found that the potatoes in every case except the second gained slightly in weight during the process of cooking. This gain was evidently due to water absorbed.

The water in which the potatoes were boiled, united with that used in rinsing them after boiling, was made up to a definite volume by adding distilled water. Aliquot portions were taken for analysis. The cooked potatoes were also dried and analyzed. In most cases the amount of each substance found by analysis in the water used in cooking them, added to the amount of the same substance found in the cooked potatoes, gave, within the limits of analytical error, the total amount of that substance calculated as being present in the raw potatoes. The weight of any substance found in the water used in cooking the potatoes divided by the weight of that same substance calculated as being present in the uncooked potatoes gave the percentage of loss during boiling. The loss of carbohydrates was estimated by subtracting the sum of the protein lost (calculated by multiplying the total nitrogen lost by 5.5) and the mineral matter lost from the total loss of dry matter.

The following table gives the loss of nutrients when the potatoes were cooked in different ways:

The loss of material during the process of cooking potatoes.

	Dry matter.	Nitrogen.			Carbohydrates.	Ash.
		Albuminoid.	Nonalbuminoid.	Total.		
Skins removed before boiling.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Water cold at beginning of test	3.7	4.3	12.9	8.3	2.5	17.0
Water hot at beginning of test	4.0	3.3	17.9	10.0	2.8	17.4
Average	3.9	3.8	15.4	9.2	2.7	17.2
Boiled with skins on.						
Water cold at beginning of test	.3	.6	.6	.6	.2	1.9
Water hot at beginning of test	.3	.4	1.7	1.0	.1	1.2
Average	.3	.5	1.1	.8	.2	1.6

It will be seen that the loss of matter during the process of cooking was confined quite largely to the nitrogenous substances and the mineral matter. The total loss of dry matter, however, was in some cases considerable, indicating a loss of starch and other carbohydrates. The loss of nitrogen and mineral matter is easily explained by supposing that substances which were dissolved in the juices simply passed out into the water. The loss of the carbohydrates, on the other hand, is probably largely mechanical.

It will be noticed that the calculated loss of carbohydrates was almost nothing when the potatoes were protected by their skins. When the skins were removed before cooking, more or less of the softened and broken cell walls and swollen starch grains were abraded during the process of boiling. Although this process is mechanical, the material removed is just as truly lost as if an equivalent amount of starch had been converted into dextrin during the boiling and then dissolved. Possibly there is a slight loss of starch which is chemical rather than mechanical. In roots, such as beets, turnips, and carrots, there is more or less sugar which might dissolve out, but the fresh potato contains practically no sugar.

CONCLUSIONS.

When potatoes are boiled with the skins removed, there is a very considerable loss not only of organic nutrients but also of mineral salts. These salts, while not nutrients in the sense in which this term is frequently used, are nevertheless important in nutrition. They are of especial value, because of the potassium compounds which they contain, and are apparently necessary for health.

The greatest actual loss of nutrients seems to be due to the mechanical abrasion of the soft outer portions of the potato while cooking. In this case nearly 3 per cent of the carbohydrates and 4 per cent of the available flesh-forming nitrogenous matter are lost. When the potatoes are boiled with their skins on, the loss of nutrients is very slight, consisting chiefly of nonalbuminoid nitrogenous substances and mineral matter. It is self-evident that if it is desired to boil potatoes with as little loss as possible the skins should be left on.

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